



# Mars Planetary Protection

Mars Scout AO Preproposal Conference

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# Planetary Protection Policy

(NASA; COSPAR)

*Planetary Protection*



- Preserve planetary conditions for future biological and organic constituent exploration
  - avoid forward contamination; preserve our investment in scientific exploration
- To protect Earth and its biosphere from potential extraterrestrial sources of contamination
  - avoid backward contamination; provide for safe solar-system exploration

Complies with Article IX of the United Nations Outer Space Treaty of 1967

# NASA Planetary Protection Documents

*Planetary Protection*



- NPD 8020.7 establishes NASA policy for planetary protection, which includes protection of planetary bodies for future exploration and of Earth from extraterrestrial sources of contamination. (Version “F” February 1999)
- NPR 8020.12 is issued to delineate a uniform set of planetary protection requirements for all NASA robotic extraterrestrial missions. Implementation of these requirements will ensure that biological safeguards are being followed in NASA's space programs. (Version “C” April 2005)
- NPR 5340.1 provides the basic procedures for performing microbial assays for assessing contamination levels of spacecraft. (Version “D”, which includes molecular methods, is in work for a 2006 or early 2007 release; a draft of version “B/C” can be provided to proposers upon request)

# Delegation of PP Authority (NPD 8020.7F)

Planetary Protection



- Management of NASA's Planetary Protection policy is delegated to the Planetary Protection Officer for:
  - » Prescribing standards, procedures, and guidelines applicable to all NASA organizations, programs, and activities
  - » Certifying to the Associate Administrator for Space Science and to the Administrator prior to launch, and in the case of returning spacecraft, prior to the return phase of the mission, prior to Earth entry, and again prior to release of returned materials, that—
    - All measures have been taken to meet NASA policy objectives
    - The recommendations of the regulatory agencies with respect to planetary protection have been considered and their statutory requirements have been fulfilled
    - International obligations have been met and international implications have been considered
  - » Conducting reviews, inspections, and evaluations of plans, facilities, equipment, personnel, procedures, and practices
  - » Taking actions as necessary to achieve conformance with applicable NASA policies, procedures, and guidelines.

# Planetary Protection Mission Constraints



- Depend on the nature of the mission and on the target planet
- Depend on current knowledge, based on internal and external recommendations, "but most notably from the Space Studies Board of the National Academy of Sciences"
- Specific measures include:
  - » Reduction of spacecraft biological contamination
  - » Constraints on spacecraft operating procedures
  - » Spacecraft organic inventory and restrictions
  - » Restrictions on the handling of returned samples
  - » Documentation of spacecraft trajectories and spacecraft material archiving

# Planetary Protection Mission Categories (NPR 8020.12C)

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PLANET PRIORITIES	MISSION TYPE	MISSION CATEGORY
A Not of direct interest for understanding the process of chemical evolution. No protection of such planets is warranted (no requirements)	Any	I
B Of significant interest relative to the process of chemical evolution, but only a remote chance that contamination by spacecraft could jeopardize future exploration.	Any	II
C Of significant interest relative to the process of chemical evolution and/or the origin of life or for which scientific opinion provides a significant chance of contamination which could jeopardize a future biological experiment.	Flyby, Orbiter	III
	Lander, Probe	IV
All Any Solar System Body	Earth-Return	V “unrestricted” or “restricted” return

# Salient Mars Planetary Protection Studies by the Space Studies Board

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- 1992 *Biological Contamination of Mars: Issues and Recommendations*, which reported advice to NASA on measures to protect Mars from contamination by Earth organisms, as well as overall policy guidance (Ken Nealson, Chair)
- 1997 *Mars Sample Return: Issues and Recommendations*, which reported advice to NASA on Mars sample return missions (Ken Nealson, Chair)
- 2001 *The Quarantine and Certification of Martian Samples*, which reported recommendations on actions to be taken to implement containment and biohazard testing measures recommended in the 1997 study (John Wood, Chair)
- 2005 *Preventing the Forward Contamination of Mars*, reported advice to NASA on measures to protect Mars from contamination by Earth organisms, based on new knowledge since the 1992, is being assessed and implemented by NASA (Chris Chyba, Chair)

# NPR 8020.12C

## Requirements for Mars Missions

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### Forward Contamination/Outbound Phase –

- **Category III Orbiter** (impact avoidance and contamination control)
  - » The probability of impact of Mars by the launch vehicle, including upper stages, shall not exceed  $10^{-4}$
  - » Assembly and maintenance in Class 100,000 (~ISO 8, or better) clean room facilities
  - » The probability of impact on the surface of Mars shall not exceed  $1 \times 10^{-2}$  for the first twenty years from the date of the launch, and  $5 \times 10^{-2}$  for the period of twenty to fifty years from the date of the launch (alternatively, the orbiter may reduce the total bioburden—surface, mated, and encapsulated—to  $5 \times 10^5$  spores by the NASA Standard Method)

# NPR 8020.12C

## Requirements for Mars Missions

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### Forward Contamination/Outbound Phase (cont.)—

- Category IV, Landers

- » Probability of accidental impact on the target planet by hardware other than the probe or lander modules (systems not meeting bioburden requirements) must not exceed  $10^{-4}$ ; carrier s/c heating may exempt it
- » Organic materials inventory for quantities  $\geq 1$  kg. Samples of not less than 50 g of each organic material present in quantities  $\geq 25$  kg
- » Category IVa: Bioburden on exposed surfaces shall be an average of  $\leq 300$  bacterial spores /  $\text{m}^2$ , and the total vehicle surface burden shall be  $\leq 3.0 \times 10^5$  bacterial spores (as assayed by the standard method)
- » Category IVb: Bioburden on exposed surfaces equivalent to Viking surface bioload (by inference, a total of 30 spores—that is,  $3.0 \times 10^5$  reduced by no more than 4 decades). Following terminal microbiological assay and any microbial reduction procedure, the Project must adequately protected against recontamination

# NPR 8020.12C

## Requirements for Mars Missions

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### Forward Contamination/Outbound Phase (cont.)—

- Category IV Landers (including landed rover[s]), cont.
  - » Category IVc: (missions investigating special regions)
    - Requirements of IVa, plus Viking post-sterilization cleanliness, at minimum, for entire landed system if landing site is *within* a special region
    - If lander accesses special region by horizontal or vertical mobility, then the entire s/c *or* subsystems with direct contact must meet Viking post-sterilization requirements, and a method for preventing recontamination prior to accessing special regions shall be provided
    - If an off-nominal condition (such as a hard landing) would cause a high probability of inadvertent biological contamination of the special region by the spacecraft, the entire landed system must be sterilized to the Viking post-sterilization biological burden levels—or you can't land there!

# NPR 8020.12C

## Requirements for Mars Missions

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### Forward Contamination/Outbound Phase (cont.)—

- A Special Region is defined as a region within which terrestrial organisms are likely to propagate, *or* a region which is interpreted to have a high potential for the existence of extant martian life forms
  - » Given current understanding, this is apply to regions where liquid water is present or may occur. Specific examples include but are not limited to:
    - Subsurface access in an area and to a depth where the presence of liquid water is probable
    - Penetrations into the polar caps
    - Areas of hydrothermal activity
    - Gullies
  - » The recent MEPAG SR-SAG document on the subject is a good start, but be cautioned that its conclusions are not authoritative

# The Viking Casserole in Its Oven (DHMR)



If you need one, be prepared to buy one!

# SSB Recommendations for Mars Sample Return (1997)

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- Samples returned from Mars should be contained and treated as though potentially hazardous until proven otherwise
- If sample containment cannot be verified en route to Earth, the sample and spacecraft should either be sterilized in space or not returned to Earth
- Integrity of sample containment should be maintained through reentry and transfer to a receiving facility
- Controlled distribution of unsterilized materials should only occur if analyses determine the sample not to contain a biological hazard
- Planetary protection measures adopted for the first sample return should not be relaxed for subsequent missions without thorough scientific review and concurrence by an appropriate independent body

# SSB Recommendations for Mars Sample Return (cont.)

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## Technology Issues

- Avoiding contamination of returned samples with organisms or organic material of terrestrial origin—

“It will be important to stringently avoid the possibility that terrestrial organisms, their remains, or organic matter in general could inadvertently be incorporated into sample material returned from Mars. Contamination with terrestrial material would compromise the integrity of the sample by adding confusing background to potential discoveries related to extinct or extant life on Mars....Because the detection of life or evidence of prebiotic chemistry is a key objective of Mars exploration, considerable effort to avoid such contamination is justified.”
- In-flight sterilization
- Sample handling and preservation
- Ensuring sample containment
- Avoiding return of uncontained martian material

# NPR 8020.12C Requirements for Mars Sample Return Missions

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- Category V, “Restricted Earth return”
  - » Unsterilized or Sterilized sample (method must be validated, verifiable)
  - » If unsterilized, absolute prohibition of destructive impact upon return ( $\text{por} \leq 1 \times 10^{-6}$ , est.)
  - » Containment throughout the return phase of all returned hardware which directly contacted the target body or unsterilized material from the body
  - » Containment of any unsterilized sample collected and returned to Earth
  - » Post-mission analyses of the unsterilized sample, under strict containment, using the most sensitive techniques. If any sign of the existence of a nonterrestrial replicating entity is found, the returned sample must remain contained unless treated by an effective sterilizing procedure

*It is considered unlikely that an unsterilized sample can be returned on a Scout budget due to both cost and timing issues associated with this last requirement.*

# AO Body

## Planetary Protection Section

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### 6.2.3. *Forward and Back Contamination*

Mars Scout investigations will also be subject to the established protocols that address forward and back contamination. In particular, it should be noted that the forward contamination of Mars is of concern, and the return of samples may be subjected to rigorous containment and biohazard testing protocols in accordance with NASA planetary protection policy (NPD 8020.7F *Biological Contamination Control for Outbound and Inbound Planetary Spacecraft* or current revision as listed in the Mars Scout Library). Therefore, all proposers must include the prevention of forward contamination in their proposals and proposed cost, and investigators proposing sample return missions must address their plans to comply with planetary protection requirements (see Mars Scout Library, Appendix C). In particular, sample-return missions must be compatible with classification as a Category V “restricted Earth return” mission under NPR 8020.12C. Compliance with these requirements is discussed further in Appendix B, Section J.7 of this AO. The additional curation costs generated by any special requirements will be borne by the mission. For additional information, proposers may contact the NASA Planetary Protection Officer, Dr. John D. Rummel (telephone (202) 358-0702; E-mail: [john.d.rummel@nasa.gov](mailto:john.d.rummel@nasa.gov))

# AO Appendix

## Planetary Protection Section

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7. Compliance with Planetary Protection Requirements. NASA's Planetary Protection Policy (see NPD 8020.7F and NPR 8020.12C) imposes certain restrictions on mission operations and spacecraft cleanliness depending on the particular type of mission (orbiter vs. lander / life detection vs. no life detection) and the specific environments on Mars to be visited. The proposal must indicate (i) the anticipated planetary protection Category of the mission under NASA directives; (ii) the proposed mission operational accommodations to comply with the anticipated requirement including organizational responsibilities; and (iii) the proposed steps to be taken for the preparation of the orbital or landed portions of the spacecraft to comply with the requirements for overall microbiological cleanliness and recontamination prevention prior to launch, if any. If appropriate, the proposal must also indicate (iv) the nature of the proposed implementation of back-contamination control and subsequent containment and testing of returned samples, or the proposed rationale for the mission to be relieved from the containment requirement. This appendix must address both intended steps to be taken for planetary protection compliance and the organization(s) responsible for implementing those steps.

*Requirements should be robust in the face of possible failure modes –*

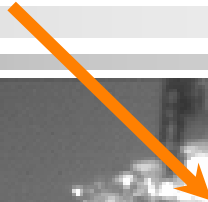


*Anticipate an accident (or two, or three)!*



# Isolation by HEPA Filter

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- Mars Pathfinder on Mars, as seen by Sojourner, showing the integrated subsystem assembly (ISA) HEPA filter
- The interior of the ISA was exempted from bioburden accounting